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SUBJECT: Effect of Manned Space Flight
Network Reduction on Skylab
Support - Case 900

DATE: May 22, 1970

FROM: J. P. Maloy

ABSTRACT

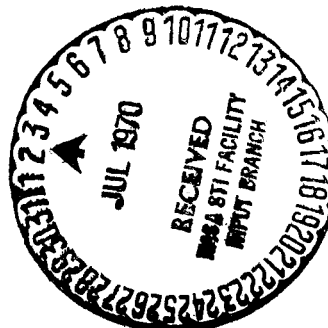
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The adequacy of support provided by a reduced complement of Manned Space Flight Network stations for Skylab missions at 235 nm altitude and a 50° inclination angle was examined. The results indicate that the MSFN stations at Texas (TEX), Canary Islands (CYI), and Guam (GWM) could be deleted with small detriment to network coverage. These stations contribute the least of the 12-station MSFN network (including Santiago) when evaluated for number of contacts, total contact time, unique contact time, and gap filling capability.

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MEMORANDUM FOR FILE

The effects of reducing the Manned Space Flight Network (MSFN) for Skylab mission support has been studied. The Apollo MSFN now consists of eleven stations: Cape Kennedy (MIL), Bermuda (BDA), Canary Islands (CYI), Ascension (ACN), Madrid (MAD), Carnarvon (CRO), Guam (GWM), Honeysuckle (HSK), Hawaii (HAW), Goldstone (GDS), and Texas (TEX). It has been proposed to add MSFN station facilities at Santiago, Chile (SAN) for Skylab missions. Six of the present network of stations have been assumed to be essential to network support for various reasons -- MIL and BDA for launch support, the 85' antenna stations (MAD, HSK, GDS) for deep space support of manned and unmanned missions, and CRO because of its antipodal geographical position from MIL. The contributions of the remaining five stations to Skylab mission support have been reviewed. These MSFN stations were ranked as possible candidates for deletion based on their contribution to the following parameters (for a Skylab mission at 235 nautical miles altitude and an orbital plane inclination of 50°):

- 1) The number of MSFN site contacts with Skylab.
- 2) The total contact time with MSFN sites.
- 3) The total unique contact time (not overlapping with any other station).
- 4) The number of additional gaps exceeding 89.0 minutes introduced when a station by itself or in combination with other stations of the five considered is deleted.
- 5) The increase in the amount of data not recorded (lost data) due to the capacity of the Apollo Telescope Mount (ATM) tape recorder if one or more stations are deleted.

This memorandum presents a comparison of the results for the first three criteria by station. Ten different sets of stations are compared for the last two criteria. This was done for minimum contact times between the station and the Skylab of three and six minutes. Finally, a suggestion is made for station deletion if a reduction in the number of MSFN stations is required for fiscal reasons.

METHOD

Twenty computer runs were made using the ALTER I* program to accumulate the basic data necessary for this station evaluation. The mission parameters were (a) an altitude of 235 nautical miles, (b) orbital plane inclination of 50° and (c) mission duration of 28 days (404 revolutions). Coverage for the following network combinations was computed in turn:

- 1) twelve stations (the eleven listed in the introduction plus the proposed Santiago station) as a control set
- 2) the 12 stations minus TEX
- 3) the 12 stations minus HAW
- 4) the 12 stations minus ACN
- 5) the 12 stations minus CYI
- 6) the 12 stations minus GWM
- 7) the 12 stations minus ACN and CYI
- 8) the 12 stations minus ACN and GWM
- 9) the 12 stations minus CYI and GWM
- 10) the 12 stations minus ACN, CYI and GWM.

The first ten runs were made using a minimum contact time of three minutes, considered a reasonable time for voice communication and collection of real-time telemetry data. The second ten runs used a six-minute minimum contact time, considered the minimum time required for a telemetry dump from the ATM tape recorder on-board Skylab. The total number of contacts and contact time was read directly from the control set. The unique contact attributed to a station or stations was determined by the difference in total unique contact time of the control set minus the unique contact time of the set minus that station or stations. The GAP sub-routine of the program listed the gaps between minimum contacts exceeding 89.0 minutes. The time by

*A Computer Program to Compute Space Vehicle Contact Time, Slant Range, and Altitude, H. Pinckernell, Bellcomm, December 8, 1964.

which a gap exceeded 89.0 minutes was considered the time that data would not be available to the station due to tape recorder limitations on Skylab.* These amounts for each set, where appropriate, were hand calculated from the computer data.

RESULTS

Number of Contacts for Each Station

Table I lists the 12 stations in decreasing order of number of contacts for the three-minute and six-minute minimum contact time cases. Table II does the same for total contact time. The five stations considered for deletion are underlined in these tables. Each of these stations in all cases except one (contact time for TEX in the six-minute case) fell in the lower half of the list. HAW, GWM and ACN are at the bottom in that order.

Figure 1 shows a comparison of unique coverage time for each of the five stations and combinations of these stations being considered for deletion. It can be seen that TEX provides the least amount of unique coverage; CYI, the second smallest amount, followed by ACN, GWM and HAW. Indicated in the bars is the percent of network (12 stations) unique contact time that that amount of station unique time represents.

Not all possible combinations of the five candidates for deletion are shown. Combinations with HAW are not presented since early data on number of gaps and lost data produced by the deletion of HAW showed that HAW should not be deleted from the network. On inspection of similar raw data, it could be seen that TEX was the prime candidate for deletion since it did not rank high in number of contacts, contact time, ranked lowest in amount of unique contact time, and did not reduce the number of gaps exceeding 89.0 minutes.

Whether the data based on six-minute minimum contacts or three-minute minimum contacts are compared, the results are relatively the same and lead to the same observations.

Number of Gaps Exceeding 89.0 Minutes

Figure 2 presents a summary of the number of gaps between station contacts exceeding 89.0 minutes that are created

*The ATM tape recorders have a nominal record time of 90 minutes; by actual measurement, they run 89 minutes or slightly more.

when a candidate for deletion or combinations of these stations are removed from the MSFN. There are 21 such gaps with the 12-station set. When TEX, CYI or GWM are individually deleted, the number of gaps is not increased. When only ACN is deleted, the number of gaps increases by four, and when only HAW is removed from the network, the number of gaps increases more significantly to 41. When the combination of ACN and GWM are eliminated, the number of gaps also increases to 41. These two antipodal stations are so positioned geographically that on some revolutions they make consecutive contacts with the spacecraft. When both are removed from the network, the gap between remaining stations exceeds 89.0 minutes 41 times over 433 revolutions.

Figure 3 shows similar data for the case where three-minute minimum contacts were considered. Although the absolute numbers are different, the relationships among stations are the same; that is, HAW then ACN and the combination of ACN and GWM would be the least desirable to remove from the network from the point of view of keeping gaps exceeding 89.0 minutes to a minimum.

Additional computer runs were made to determine the size and number of gaps exceeding 50.0 minutes when CYI, GWM and TEX are deleted from the network. This data and their comparison with the 12-station set is presented in Figure 4 and indicates that the size and number of gaps created by having the lesser number of stations is not prohibitive.

Amount of Lost Data

That amount of gap time that exceeds 89.0 minutes between contacts is considered as lost data time since data would not be recorded due to the capacity of the tape recorder on-board Skylab.* The size of gaps exceeding 89.0 minutes was examined, and the amount of lost data time was calculated for each set of stations for the six-minute minimum contact case. A six-minute station contact is always required to dump the data from the tape recorder. This is independent of gap size and is due to the design of the recorder.

There would be the greatest increase (over 1600 minutes) in the amount of unrecorded data if HAW were deleted from the network of stations when considering any single station of the five candidates for deletion. ACN is the only other single station

*A second tape recorder is held in a standby status and could, with some operational difficulty, be used serially with the first.

whose elimination would increase the amount of lost data (by almost 600 minutes). As in the case of the number of gaps, the amount of lost data would compound (over 1000 minutes) if both ACN and GWM were removed from the set of 12 stations.

SUMMARY AND CONCLUSIONS

The possibility of reducing the number of stations in the MSFN for Skylab support by up to five stations was examined. These stations were evaluated against the parameters of number of contacts, total contact time, unique contact time, number of gaps and amount of lost data for a Skylab mission designed at 235 nautical mile circular orbit, at an orbital plane inclination angle of 50° for 28 days. All five of the candidates for deletion (TEX, HAW, ACN, CYI and GWM) ranked in the lower portion of the MSFN for number of contacts and total contact time.

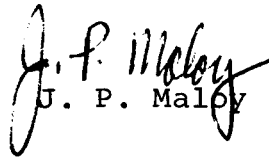
By inspection, it was determined that TEX could be removed because it contributed nothing towards reducing the number of gaps and lost data since it lies between Goldstone and Cape Kennedy stations. The computer data confirmed this and in addition, TEX ranked last in the amount of unique contact time it contributed to the MSFN coverage. On the other hand, it became apparent that HAW was valuable for Skylab support because without it the number of gaps exceeding 89.0 minutes doubled in the six-minute minimum contact use and quadrupled for the three-minute minimum contact use. In addition, the amount of lost data would be tripled without HAW.

CYI would be the second candidate for deletion from the MSFN. It also has no effect on reducing the number of gaps exceeding 89.0 minutes and the amount of lost data. CYI also contributes the second smallest amount (<450 minutes) of unique coverage time. GWM likewise has no effect on reducing the number of gaps exceeding 89.0 minutes and the amount of lost data, but contributes more unique coverage time (approximately 860 minutes). The omission of ACN would increase the number of gaps (from 21 to 25 for the six-minute minimum contact case) and the amount of lost data by almost 600 minutes. In addition, if GWM were deleted along with ACN, the number of gaps and lost data would increase by significantly more (by 20 and more than 1000 minutes, respectively) than their singular effects. This is because of their geographical relationship along the sub-vehicle track of Skylab. Finally, deletion of HAW is less attractive than deletion of any other single station since it would increase the number of gaps markedly (from 21 to 41) and the lost time by 1600 minutes.

The conclusion is that for a Skylab type mission as described in this memorandum, the deletion of TEX, CYI or GWM as a single station or in some combination would have the least effect on mission support in the order named.

A memorandum by J. E. Johnson* extends the results of this study to consider the need for support by the MSFN of Apollo Lunar Surface Experiment Packages (ALSEP's) and a lunar subsatellite in the Skylab time frame.

2034-JPM-drc



J. P. Maloy

Attachment
Tables 1 and 2
Figures 1 thru 5

*"Combined Skylab and Lunar Support with a Reduced Manned Space Flight Network," J. E. Johnson, Memorandum for File, May 22, 1970.

TABLE 1

COMPARISON OF NUMBER OF CONTACTS

(235 nm alt.; 50° incl. angle; 28 day mission)

<u>3 Minute Minimum Contact</u>			<u>6 Minute Minimum Contact</u>		
<u>Sta.</u>			<u>Sta.</u>		
1	BDA	202	1	GDS	189
2	SAN	197	2	HSK	185
3	GDS	197	3	MAD	173
4	HSK	195	4	SAN	150
5	MAD	185	5	BDA	146
6	MIL	153	6	MIL	126
7	<u>TEX</u>	147	7	<u>TEX</u>	122
8	<u>CYI</u>	147	8	<u>CYI</u>	119
9	CRO	138	9	CRO	115
10	<u>HAW</u>	130	10	<u>HAW</u>	109
11	<u>GWM</u>	116	11	<u>GWM</u>	98
12	<u>ACN</u>	109	12	<u>ACN</u>	95

TABLE 2

COMPARISON OF TOTAL CONTACT TIME (MIN)

(235 nm alt.; 50° incl. angle; 28 day mission)

<u>3 Minute Minimum Contact</u>			<u>6 Minute Minimum Contact</u>		
<u>Sta.</u>			<u>Sta.</u>		
1	MAD	1660	1	GDS	1621
2	GDS	1658	2	MAD	1614
3	HSK	1642	3	HSK	1597
4	SAN	1541	4	SAN	1313
5	BDA	1530	5	BDA	1281
6	MIL	1240	6	<u>TEX</u>	1207
7	<u>TEX</u>	1206	7	MIL	1114
8	<u>CYI</u>	1201	8	<u>CYI</u>	1064
9	CRO	1125	9	CRO	1015
10	<u>HAW</u>	1061	10	<u>HAW</u>	965
11	<u>GWM</u>	948	11	<u>GWM</u>	867
12	<u>ACN</u>	908	12	<u>ACN</u>	840

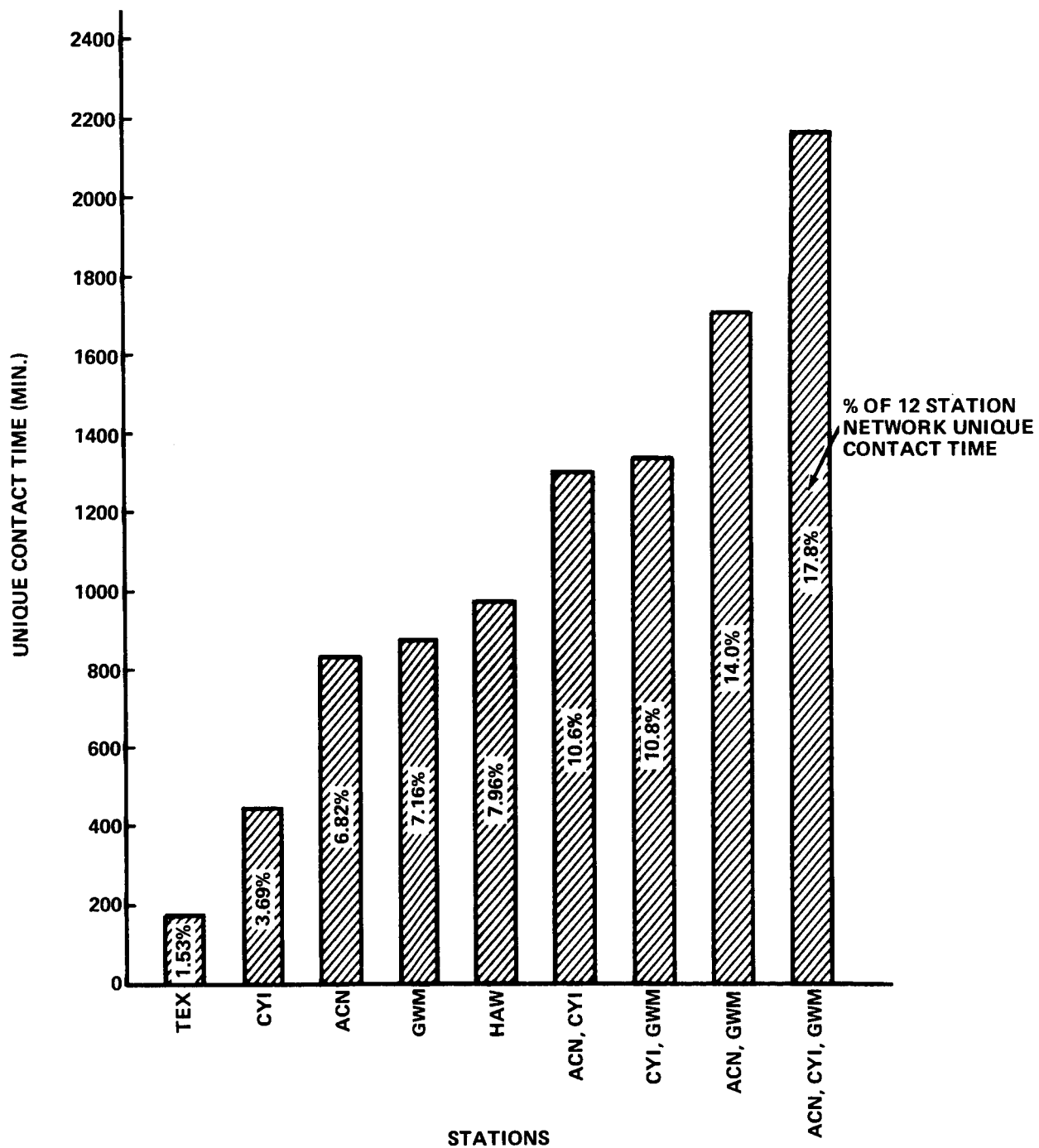


FIGURE 1 - STATION UNIQUE CONTACT TIME
(6 MIN. MINIMUM CONTACT)

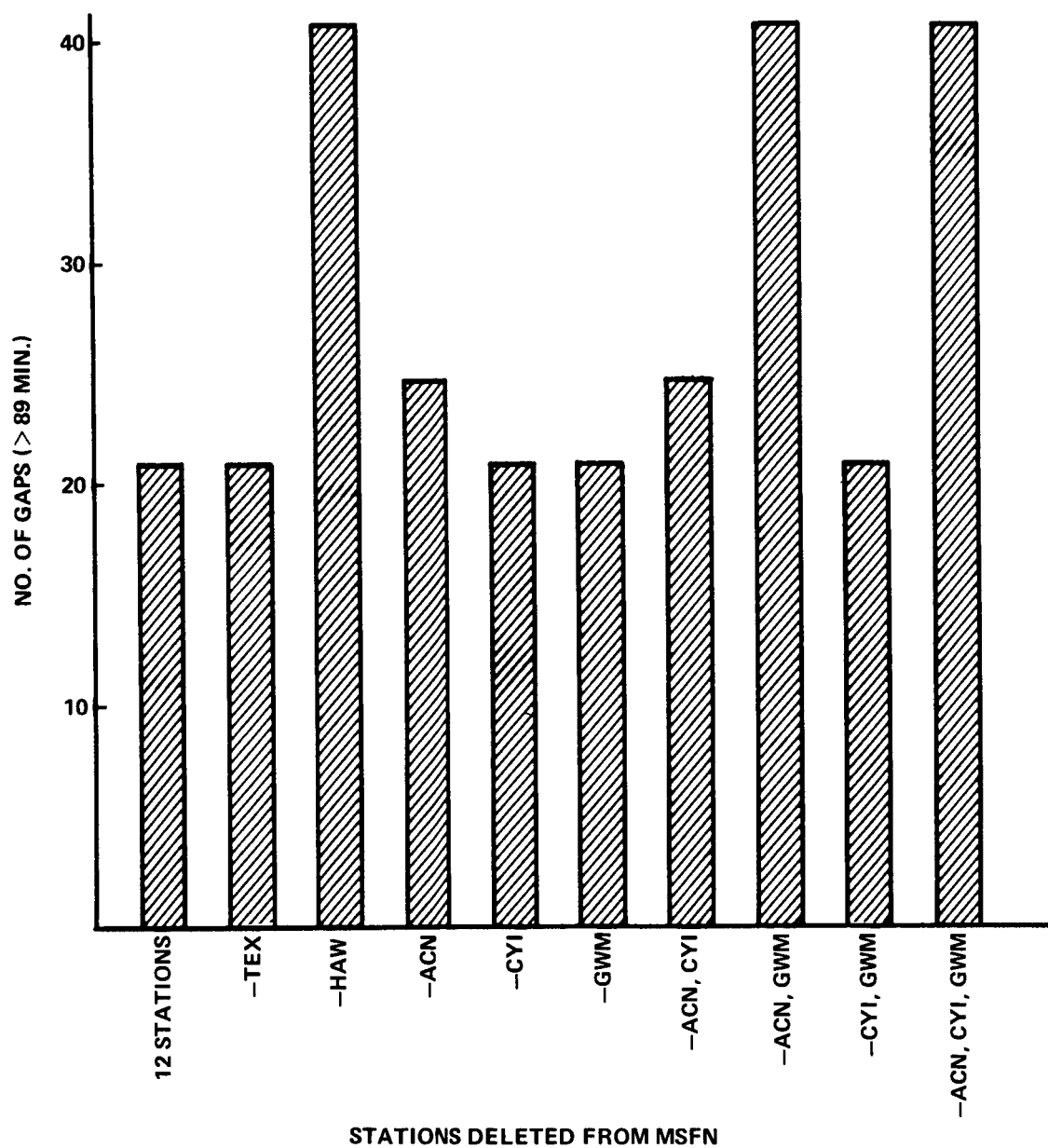


FIGURE 2 - NUMBER OF GAPS (> 89 MIN.) VS. STATIONS DELETED FROM MSFN
(6 MIN. MINIMUM CONTACTS)

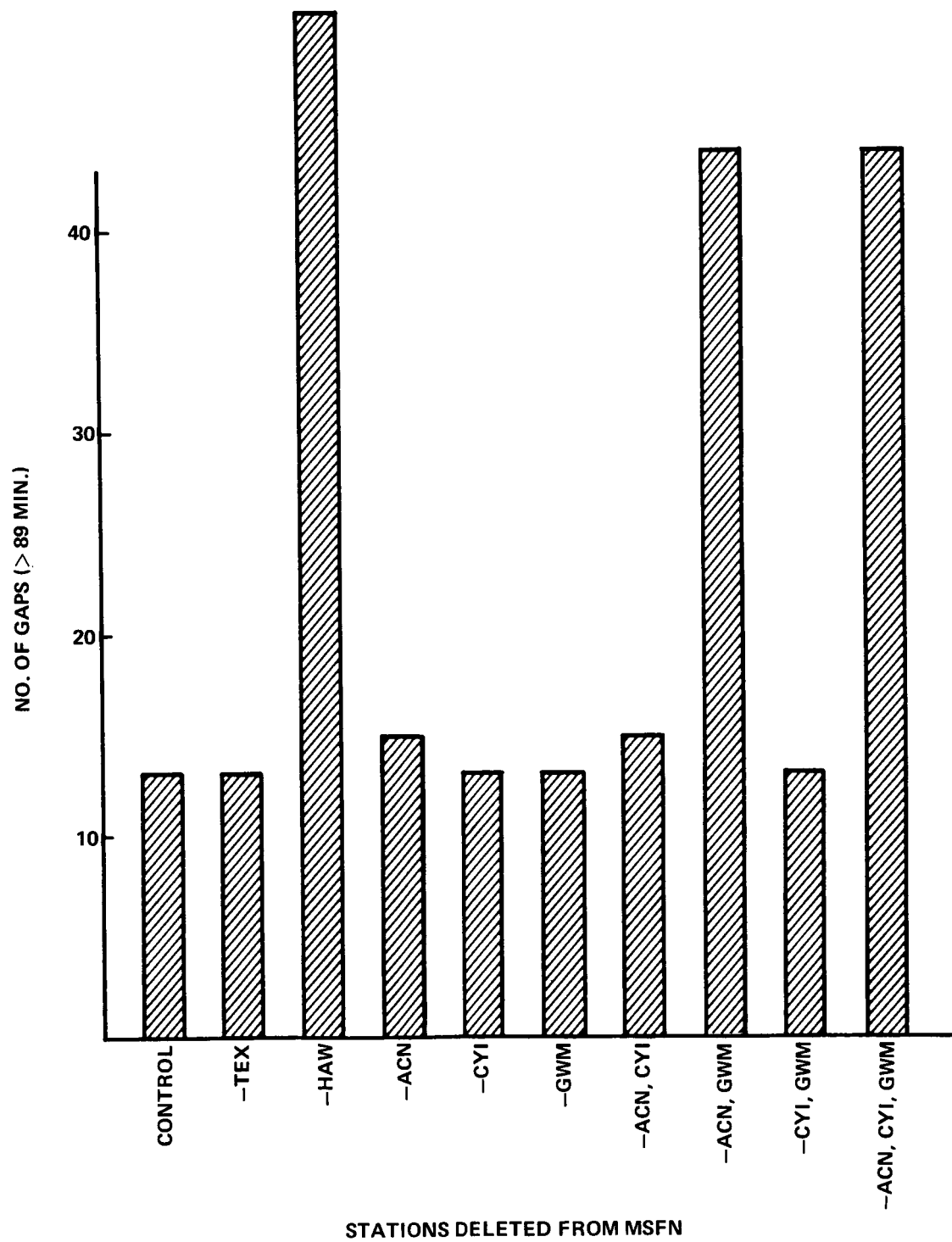


FIGURE 3 - NUMBER OF GAPS (> 89 MIN.) VS. STATIONS DELETED FROM MSFN
(3 MIN. MINIMUM CONTACTS)